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GB 2229305 A

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UK CL (Edition O) **G4R RHB RPF RPX RRL RRM**
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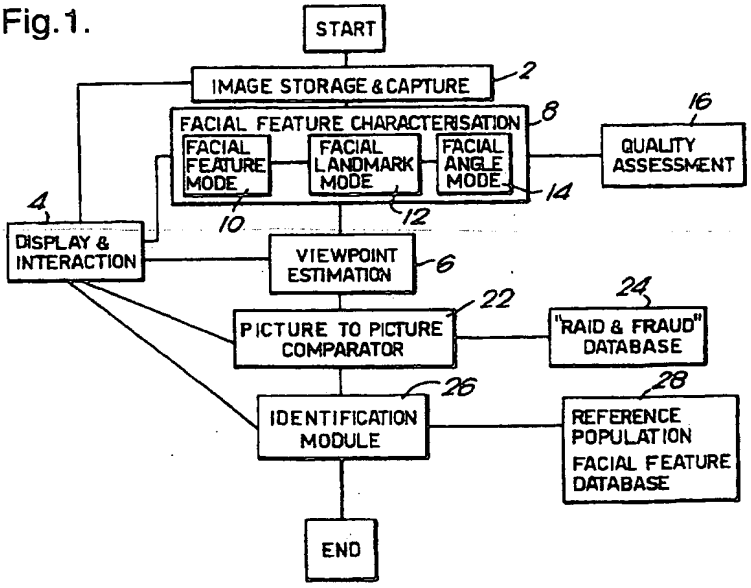
(54) Facial identification

(57) A method of identifying a facial image records characteristic facial features from a facial image, compares the recorded facial features with a database of similar characteristic facial features derived from a reference set of facial images, and determines from the comparison the statistical probability that any combination of the recorded facial features may occur in any two persons.

Fig.1.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

GB 2 308 712 A

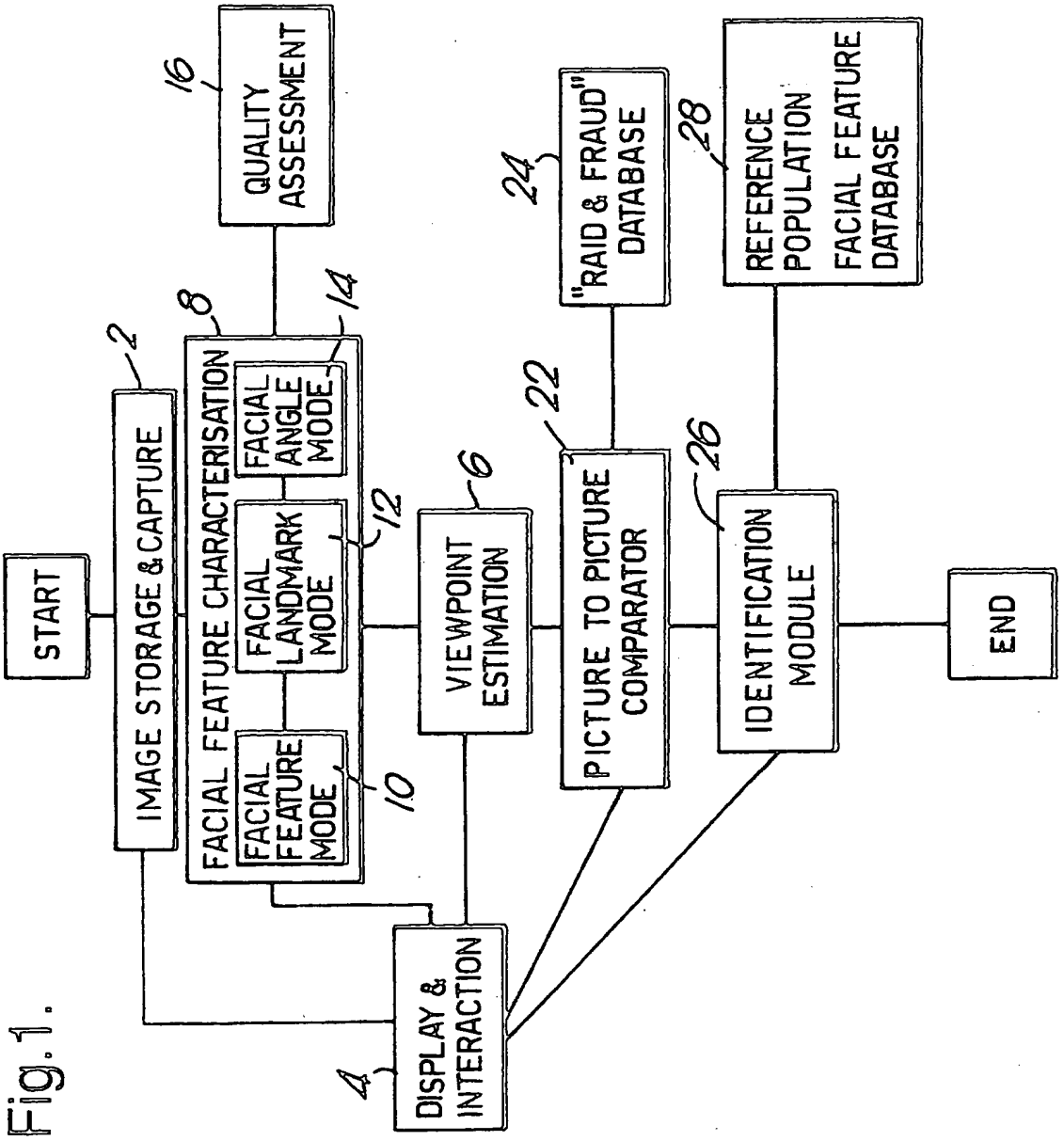
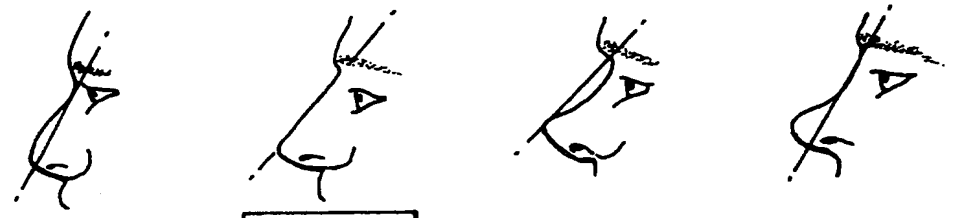

START
IMAGE STORAGE & CAPTURE
2
FACIAL FEATURE CHARACTERISATION
8
FACIAL FEATURE MODE
10
FACIAL LANDMARK MODE
12
FACIAL ANGLE MODE
14
QUALITY ASSESSMENT
16
DISPLAY & INTERACTION
4
VIEWPOINT ESTIMATION
6
PICTURE TO PICTURE COMPARATOR
22
"RAID & FRAUD" DATABASE
24
IDENTIFICATION MODULE
26
REFERENCE POPULATION FACIAL FEATURE DATABASE
28
END

Fig. 1.

Fig.2.

32

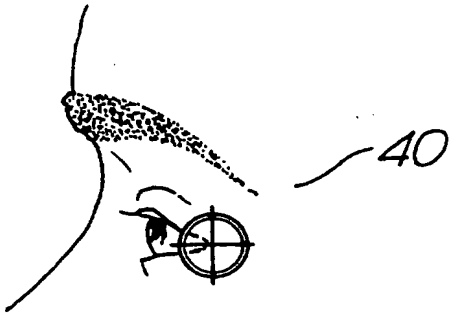

CONVEX
STRAIGHT
CONCAVE
BULB

34


TRI RECT
TRIANGLE
RECTANGULAR
OVAL
ROUND

36

Fig.3.



Apparatus and Methods Relating to Facial Identification

This invention relates to the identification of persons by reference to characteristic facial features.

Facial recognition by an automated system or machine has in recent years become a growing field of research for both academics and engineers alike. The growth of this technology has been aided by the advent of more powerful and capable computing hardware, software techniques and surveillance systems which have enabled practical and usable recognition systems to be developed. Such systems are predominantly being developed for purposes such restricted entry door security and access to secure computing networks, along with research into areas such as facial recognition for use in access sequences to bank ATM machines. By their very nature, such systems tend to operate on a restricted set of candidate faces and as such the recognition element of such systems is limited to that particular application.

Due to the growing need in the criminal justice system attendant on the growth of surveillance imaging, a body of research in the field of recognition systems has been directed towards facial identification of suspects for use in judicial proceedings. In the case of criminal prosecutions where the identity of a suspect is at issue, the level of certainty required for a conviction is defined by the British legal system as being ' beyond all reasonable doubt'. Many legal arguments and case specific issues may affect a jury's decision but, more recently, photographic and/or surveillance video information is beginning to play an increasingly important role in helping the courts reach decisions. Recent court rulings have suggested that when computer based facial image analysis systems are used for judicial purposes, a

quantifiable probability of the chosen system producing what is known as 'false positives' is required, i.e. the wrong person 'positively' identified as the criminal. It will be appreciated that in terms of public confidence in both the police force and the judicial system, the reduction and eventual elimination of false positive identifications is of great importance.

Recognition systems have been proposed for a range of applications but to date none have sought to quantify the probability of a false positive identification being made when the method employed relies on the statistical identification of selectable comparative facial features. This point is the particularly important when considering the use of such techniques applied to pictures or video stills intended for use as court evidence.

State of the art facial analysis systems tend to deal with the application known as recognition. In this sense recognition relates to the selection of one face from a restricted group of candidate faces as being a match for the particular face under analysis. Recognition systems, such as that detailed in WO 92/08202 A1 are designed to extract a global statistical description of an unknown face in order to enable such a match comparison to be made between that description and a set of similarly constructed descriptions of a restricted set of faces. The system works by comparing some numerical values of the statistical description or global descriptor of an unknown face with those descriptors of a candidate face. If the comparison reveals agreement within a selected threshold then the system declares the unknown face as recognised.

Apparatus for extracting characteristic facial points from an image and applying a technique known as edge extraction to inputted facial image data is disclosed in European patent

application No. 0 552 770 A2. The technique centres on a method for the analysis of facial features related to changes in the brightness gradient of adjacent pixels analysed from a suitably digitally stored image. This boundary information is then compared with a limited list of predetermined feature shapes, which are anticipated as being located in a particular region of the facial image under analysis, whereupon an automatic selection of one such feature shapes from the list is made. No details of the 'person identification system' discussed in the introduction to EP 0 552 770 A2 is disclosed therein and furthermore no method of determining the probability of false recognition is given. There are of course many applications for such a system, but the automatic recognition of facial characteristics by such a method would not carry the level of certainty required for a system designed for the forensic comparison of facial images.

A face classification system proposed for use in extracting a face from a two dimensional representation of a three dimensional scene is described in European patent application No. 0 551 941 A2 . The system proposes a method of rotation, scaling and grey level intensity invariant representation of a facial image to produce a substantially unique 'feature vector' therefrom. This 'feature vector' can subsequently be analysed for statistical correlation with a set of known 'feature vectors'. This type of system should be referred to as a pure recognition system by virtue of the fact that its purpose is to recognise and match data collected from a recorded facial image, in order to give a output control signal of either 'face recognised' or not as the case may be. The system makes no reference to measurements of statistical probability or accuracy in relation to any comparison made, nor does the disclosed invention make use of a comparative database of collected known human facial features on which to base it's recognition decisions.

European patent application No. 0 582 989 discloses a system for recognising a person from a limited set of up to 100 people. The invention discloses two methods of characterising automatic recognition. The first is the iconic, based on comparisons of images with stored templates, and the second geometric, which is concerned with the computation coefficients to form 'reference vectors' for facial images to allow subsequent comparison with a set of such vectors for known people. The prior art system makes use of both of the above recognition techniques, but is intended for use in a 'yes or no' type recognition scenario and is furthermore dependant on standardised viewing conditions for the face under analysis. Applications for such a system may include use as a control means for a door access control system in which a repeatable viewing position for a face under analysis is possible.

The present invention provides an identification system capable of analysing two facial images and quantifying the probability that they are the same person based on a reference to a database of facial features.

It is therefore an object of the invention to provide both apparatus and a method to enable the quantitative comparison of facial images, based on the analysis of physical features and standardised facial measurements taken from said facial images, with reference to a database of measured human facial characteristics, such that the system provides a quantifiable estimate of the probability of any identification made being falsely positive.

Accordingly there is provided a method of identifying a facial image, comprising the steps of; recording characteristic facial features derived from a facial image; comparing said recorded

facial features with a database of similar characteristic facial features derived from a reference set of facial images, and determining from the comparison, the statistical probability that any combination of said recorded facial features may occur in any two persons.

The invention will now be described by way of a non-limiting example, with reference to the following drawings, in which;

Figure 1 shows a flow diagram of system in accordance with the invention.

Figure 2 is a diagrammatic representation of a face with selected features indicated

Figure 3 is a diagrammatic representation of a face with selected facial landmarks indicated

In figure 1 , a flow diagram of a system operating in accordance with the invention is shown. An image data capture and storage means 2, which could comprise a digital scanner or digital camera , is used to capture an image for forensic comparison. The image is loaded into a storage means such as CPU RAM to enable the data to be stored in a manner that enables repeatable use of such data for the purposes of possible future identification.

The facial feature characterisation system 8 is designed for use by a trained operator, the interface with said operator being via a display and interaction means 4, which would typically take the form of a computer terminal and screen. The image for assessment is displayed on said screen and the operator is presented with typically three modes relating to separate

methods of describing facial characteristics, namely facial feature selection 10, facial landmark selection 12 and facial angle selection 14.

The facial feature characterisation system 8 allows the operator to make and record facial feature selections based matching descriptive features to the image taken from a number of predetermined facial features, an example of which is shown in figure 2. The facial landmark selection mode allows the operator to make and record a series of predetermined measurements of particular facial characteristics examples of which are shown in figure 3 . The facial angle selection mode allows the operator to make and record a series of measurements based on the angles of projected lines oriented on specific features of the facial image under analysis.

A Quality Assessment Module 16 connected to the facial feature selection means 8 is configured to analyse the operator selected measurements and assess the quality of the measurement process. The quality is quantified by using an assessment method that tests the operators ability to repeat any measurements taken, by requiring said operator to perform certain measurements more than once. This measurement of repeatability is an essential feature of the process due to the stringent certainty requirements required for use by the judicial system. Once the details of the images have been captured and stored, the images may then, if required, be passed to the viewpoint correction module 6.

The picture to picture comparitor means 22 enables the operator to request the system to compare features selected using the various modes of the facial feature selection system 8 with a 'known criminal' database 24. This database 24 contains details of measured facial features

of known persons faces. The comparitor means 22 enables the system to select one or more faces from it's database of known faces as a possible match or matches for the face under analysis.

The identification means 26, enables the operator to request the system to compare the features selected using the various modes of the facial feature selection system 8 with a 'reference population facial feature database' 28. The database 28 contains the facial measurements, angle and feature classifications as recorded from a range of the population. The selected features included in the database 28 are those available to the operator to select when using the facial feature selection system 8 when operating on the facial image under analysis.

The viewpoint correction module 6 is used to correct any angular errors present in images supplied for comparison, for example from surveillance cameras placed at obscure angles. Such errors may render captured facial images not immediately suitable for analysis, but the viewpoint correction module 6 helps to correct or compensate for such errors so as to enable the subsequent measurement of the particular facial characteristics required for the identification process. .

The identification module 26 uses the results of the facial feature measurements, angles and classifications, made and recorded by the operator, in relation to the two faces presented for comparison, and calculates the statistical significance of any similarities found in the said facial feature measurements, angles and classifications of both images.

The significance of any similarities between images under analysis is quantified by the use of two recognised statistical methods, calculation of the percentage of the entries on the database 28 that match the particular features, angles or measurements selected for comparison, and the calculation of the probability of any pair of entries having matching selected facial features, angles or measurements.

When used as an identification system in judicial proceedings the following sequence of events illustrates an example of how the system could be utilised. If surveillance video camera footage from the scene of a crime has been recorded, then the police may have a particular suspect whom they believe to have committed the crime. For a particular case to stand a chance of progressing, the police may require further identification evidence to support their claim. Once detained, the suspect's face will be photographed in both anterior and profile views, and entered onto the system using the image capture and storage means 2.

A trained operator using the facial feature selection system 8 would recall the picture taken from the subject under suspicion. Using the system, the operator will then go through the process of characterising the facial features of the recorded picture by using the three modes available, namely 'facial feature selection' 10, 'facial landmark selection' 12 and 'facial angle selection' 14.

Figure 2 shows a typical profile view of a face 32 under analysis as presented to an operator using the invention. The face 32 is presented in profile during one part of the facial feature selection process 10 such that features such as the nose and ears may be characterised. The operator selects features he can clearly define and matches these to a range of presented

features, examples of such selections including noses 34 and ears 36. A number of such features are selected in both profile and anterior view by the operator to enable a characteristic facial feature reference to be compiled for the face under analysis.

Figure 3 shows a typical profile view of a face 38 under facial landmark analysis. The face 38 is show presented in profile such that the operator can select a facial landmark relating to the outer canthus of the eye 40. The operator is then requested to select the point of the outer canthus 40. The operator then moves to further landmark areas of the face as defined by the system in both profile and anterior views, which may include amongst other measurements nose width, mouth width and ear protrusion.

A similar process of anterior and profile views is required for the analysis of the third facial characteristics selection mode, namely facial angle selection 14. This mode requires the operator to move and orientate and locate projected lines onto specific facial features of the displayed facial image under analysis. The positioning of these lines in relation to specific facial features forms characteristic angles for a particular face.

During facial feature characterisation process 8, the quality assessment module 16 records and assesses the inputs of the trained operator. This process is conducted in order to quantify the quality of the responses and inputs made to the system. This process involves the structured repetition of certain measurements and feature selections in order to assess the repeatability of the operators responses. This enable the system to give a case by case quantitative estimate of the quality of the analysis which can be presented to the courts as evidence of the comparative quality of each particular identification.

The information recorded from all threes modes 10, 12 and 14 is fed into a reference population facial feature database 28 whereupon it is stored along with all other recorded facial reference information which has undergone the same process. Once the process of entering the fist image onto the system is complete, the operator may then enter the crime scene image, with which the suspect is to be compared.

The identical process using of the facial feature selection system is applied to the crime scene image and thus the facial image data relating to each of the selection modes, 10, 12 and 14 is recorded. The picture taken at the crime scene may show the criminal with his face at an angle to the camera and as such the viewpoint estimation means 6 may be used after the facial feature characterisation process 8 has been completed to correct any distortions due to the viewpoint that may be present

Utilising the 'identification' element of the described system, once the crime scene image has undergone the operator controlled selection system 8 process, the system can then be requested to compare the data extracted from the crime scene image with that of the suspect whose data has previously been entered. The system then compares the characteristic features of both facial images and calculates the percentage match of the selected features compared to the reference population facial feature database 24 , for example what percentage of faces in the reference database 24 have the same ear shape combined with nose width combined with eye spacing. The use of the combination of selected features provides a very accurate quantitative method of assessing the likelihood of whether the person pictured at the crime scene is in fact the suspect who has been subsequently subjected to facial feature analysis.

The system further calculates the 'pair score' for the two images under comparison, namely the probability, based on the information contained in the reference database 24, that the features selected for analysis would occur in any two persons. It is this particular statistic that enables the operator, and in turn the courts to assess the likelihood of false positive identification by giving a quantitative estimate of the chance of the suspect and criminal being the same person.

Alternatively, the results of the feature classification process conducted on a surveillance image can be compared to a 'raid and fraud' database 24. This database 24 holds the results of feature characterisations of known criminals and as such can be utilised by the picture to picture comparitor 22 to give quantitative estimates for matches of the surveillance image to said 'known criminals' from the database 24. The same statistical analysis methods utilised for the 'identification' process are applied to this type of facial image comparison and consequently the results are presented with a quantitative estimate of the likelihood of a match. These results can then be used by the police to request that person who are identified as a possible match be photographed and further analysed.

Claims

1) A method of identifying a facial image, comprising the steps of;

recording characteristic facial features derived from a facial image;

comparing said recorded facial features with a database of similar characteristic facial features derived from a reference set of facial images, and;

determining from the comparison, the statistical probability that any combination of said recorded facial features may occur in any two persons.

Patents Act 1977 13 Examiner's report to the Comptroller under Section 17 (The Search report)	Application number GB 9525800.0
Relevant Technical Fields (i) UK Cl (Ed.O) G4R (RHB, RPF, RPX, RRL, RRM) (ii) Int Cl (Ed.6) A61B, G06K; G07C	Search Examiner J DONALDSON Date of completion of Search 24 JANUARY 1996
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE: WPI	Documents considered relevant following a search in respect of Claims :- 1

Categories of documents

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Y:	Document indicating lack of inventive step if combined with one or more other documents of the same category.	E:	Patent document published on or after, but with priority date earlier than, the filing date of the present application.
A:	Document indicating technological background and/or state of the art.	&:	Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2229305 (B.T.) see page 3, line 9 to page 4, line 20	

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